M. Brun
Ocurent.

A LECTURE July 1860

ON THE STORM IN WILTSHIRE,

Which occurred on the 30th of December, 1859.

READ AT A MEETING OF

THE BRITISH METEOROLOGICAL SOCIETY,

HELD ON MARCH 21, 1860, AT 25, GREAT GEORGE STREET, WESTMINSTER.

By G. A. ROWELL,

HONORARY MEMBER OF THE ASHMOLEAN SOCIETY, AND LATE ASSISTANT UNDER-KEEPER OF THE ASHMOLEAN MUSEUM.

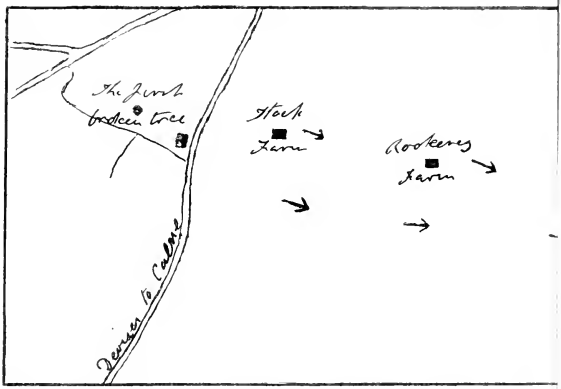
PRINTED AT THE REQUEST OF THE SOCIETY.

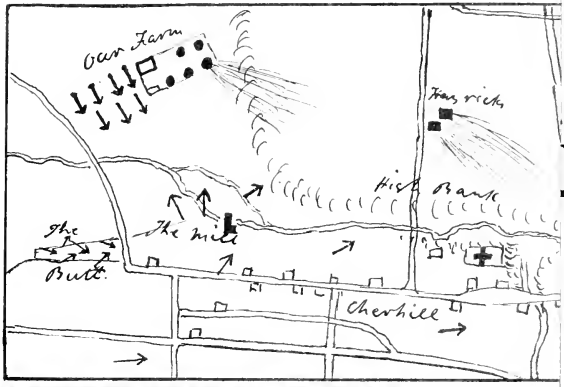
OXFORD:

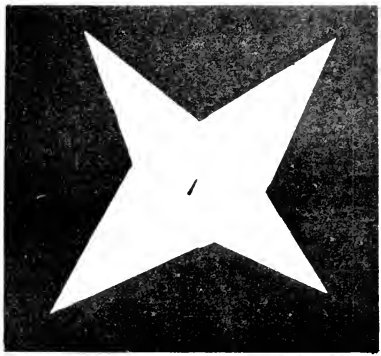
PUBLISHED AND SOLD BY THE AUTHOR,

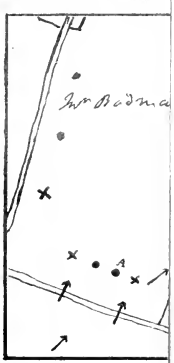
No. 3, ALFRED STREET, ST. GILES'.

M.DCCC.LX.


The Lone
broken tree
Hook
Farm
Rookery
Farm
Derby to Calow


Oar Farm
Hay rick
High Bank
The
Butts
The mill
Cherhill




Mr Bodma

A LECTURE

ON THE STORM IN WILTSHIRE,

Which occurred on the 30th of December, 1859.

READ AT A MEETING OF

THE BRITISH METEOROLOGICAL SOCIETY,

HELD ON MARCH 21, 1860, AT 25, GREAT GEORGE STREET, WESTMINSTER.

BY G. A. ROWELL,

HONORARY MEMBER OF THE ASHMOLEAN SOCIETY, AND LATE ASSISTANT UNDER-KEEPER OF THE ASHMOLEAN MUSEUM.

PRINTED AT THE REQUEST OF THE SOCIETY.

OXFORD:

PUBLISHED AND SOLD BY THE AUTHOR,

No. 3, ALFRED STREET, ST. GILES'.

M.DCCC.LX.

The first portion in the following pages is given nearly as delivered in the Lecture, and the second is essentially so; but as the description of the storm was given from short notes or memory, it may differ in some degree, especially as I have availed myself of a subsequent visit to the storm track, and also of an account of the storm by the Rev. A. C. Smith, rector of Yatesbury, published in the *Wiltshire Magazine*.

I take this opportunity to express my thanks for the very ready assistance generally afforded me on my visit to Calne, where all classes seemed imbued with a like desire to promote an investigation of the phenomena of the storm: I may especially name Mr. Alderman J. N. Ladd, through whose active exertions I was enabled to gain much information which I might not otherwise have obtained. But to none am I so deeply indebted for assistance as to the Rev. A. C. Smith, not only for the kindness and patience with which he has supplied me with plans, and answered my inquiries on minute details, that most persons would have thought frivolous, but also for permission to take extracts from his account: thus enabling me to give *pictures* of the storm in much stronger colours than I could have produced, and also giving his authority to statements that might have been considered doubtful if resting on my own authority only, and perhaps have led to the idea that I had been imposed on in my inquiries.

G. A. R.

OXFORD: PRINTED BY JAMES WRIGHT.

ON THE STORM IN WILTSHIRE,

On the 30th of December, 1859.

1. FROM the extraordinary accounts, given in the public papers, of the late storm in Wiltshire, I was induced to visit the district where it occurred, and not only found that its effects were in accordance with the description of them, but also that some of the phenomena of the storm were of such a curious and striking character, that I believe the subject to be well worthy of investigation, and deem myself very fortunate in being enabled to bring it under the consideration of this Society.

2. I spent three days in examining the effects of the storm, and have since then been assisted with many details on points of importance. I may therefore assert, that astounding as some of my statements may be, they are grounded on facts that have come under my own observation, or on authority that may be fully relied on. My object was not to look on the effects of the storm as something to wonder at, but to see what light they might throw upon the cause of storms, and it is with this view I bring the subject under your consideration.

3. Nearly all the accounts of the storm describe it as a whirlwind: this may, in general, be considered a vague term, as storms are often described as whirlwinds, if of a violent character, and confined within narrow limits—without any consideration as to whether the wind moved in circles or not: but in this case it was stated, that the effects of the storm gave full proof of its cycloidal character, and some of the writers stated the number of yards which they supposed the diameter of the cyclone to be. I very carefully examined the effects of the storm, over four miles of its track from the place of its commencement, within which

space its principal effects were exhibited: I have also obtained information respecting it from every available quarter, and really can find no proof whatever of this storm being a cyclone, or of there having been any whirling of the wind whatever, further than the mere eddies, which all fluids in rapid motion would be liable to, when subject to such obstructions as the wind generally meets with in passing along the surface of the earth.

4. I think it impossible that many of the effects of the storm could have been produced by the wind blowing either in circles or direct; and believe that the only cause which can be assigned for them is, that they were the result of a vacuum or rarefaction produced in the heavy rain-cloud which accompanied the storm; and that the destructive effects of the storm were either from the expansion of the air within or beneath the buildings, &c. over which the cloud passed, owing to the diminution of atmospheric pressure above them, or from the rush of heavier air into the rarefied space produced by the passing of the storm cloud. On this head I feel so convinced, that I shall not at present allude to the theory of cyclones, or of winds in general; but before I describe the effects of the storm, it may be well to notice the theories which have been advanced, to account for the production of such a rarefaction as that to which I attribute this storm; as a consideration of the effects of the storm, may show how far these theories can be accepted, as explanatory of the cause by which they were produced.

5. At the Meeting of the British Association in 1840, Mr. Espy explained his theory to account for the production of upward currents of air, which he assigned as the cause of storms. This theory has received much attention, and is given very fully in the report of that Meeting. As it is probably well known to every member of this Society, it may appear unnecessary for me to offer any explanation on the subject; but as I wish to make a few observations on the theory, I will give it as briefly as possible.

6. Mr. Espy stated, "That he had visited the tracks of 18 tornadoes, and examined several of them with great

care, and found that all the phenomena told one tale—the inward motion of the air to the centre of the inverted cone of cloud as it passed along the surface of the earth." From all these facts he inferred that there is an inward motion of the air towards the centre of storms from all sides.

7. His theory is, that when the air near the earth's surface becomes more heated, or more charged with vapour, up-moving columns or streams will be formed; the vapour thus carried up, on becoming condensed, gives out its latent heat to the air, causing a further expansion of the air, and a further rise; when more air, and consequently more vapour, rising into the rarefied space thus produced, the like condensation of vapour, and consequent rarefaction and rising of the air, would still go on.

8. Mr. Espy considered that the heat thus produced by the condensation of vapour would sometimes render the rising column of air 30 or 40 degrees higher in temperature than the surrounding air at such heights, and that "drops of rain might frequently be carried high enough to freeze them, and form hail, especially if they were thrown out above, so as to fall outward into the clear and colder air." He gave it as a probability, "that in all violent thunderstorms in which hail falls, the up-moving currents are so violent, as to carry drops of rain to a great height, when they freeze and become hail;"—and he considered "it difficult, if not impossible, to conceive any other way in which hail can be formed in the summer, or in the torrid zone." I cannot of course do justice to that gentleman's views in so short an explanation, but I believe I have given the main grounds of the theory.

9. Mr. Hopkins, in his work "On the Atmospheric Changes which produce Wind and Rain," takes a similar view as to the effect of condensation of vapour in producing upward currents of air; as he says, "Heat is undoubtedly the great agent in producing atmospheric movements, and it is occasionally conveyed in vapour to particular heights in the atmosphere, where it is liberated by the condensation of the vapour. Now vapour at a certain height, which, on being condensed, will form a cubic foot of water, liberates

heat enough to expand the atmosphere with which it is in contact, say 8000 feet. On the weight of this column of air being thus made less than that of the adjoining columns, contiguous air would press in to fill up the comparative vacuum, and would become an ascending column similar to heated air in a chimney. For the adjoining air being equally charged with vapour would, when it reached an adequate height, have its vapour also condensed, furnishing more heat; and the process might be continued as long as there was a sufficient supply of vapour."

10. There seems to me to be one great objection to this explanation of the phenomenon, at least as far as regards the storm under consideration; for if the condensation of vapour does produce such heating effects, and if the latent heat so liberated can produce such rising columns of air, the very heavy fall of rain which accompanied this storm must have been the result of such an enormous condensation of vapour, that the heat produced by it must, I believe, have put a stop to all further condensation at the time; whereas similar torrents of rain accompanied the storm throughout.

11. It cannot be doubted that heat is an important agent in evaporation, but there are many facts which shew, that in the ascent of vapour, the suspension of clouds, and other meteorological phenomena,—some other powerful agent is in operation. It is known that ice must absorb 140° of heat to convert it into water, without any sensible increase of its temperature[a]; and yet it has been proved that evaporation

---

[a] It is quite unnecessary, as far as regards the generality of my readers, for me to offer any proof of the absorption of latent heat by ice in melting, but it may not be so to all. I therefore give the following, thinking it best to err on the right side.

It was proved by Dr. Black that 140° of heat are lost, or become latent, during the melting of ice. This was shewn by a variety of experiments, but a description of one will suffice. If any quantity of water, say 1lb, at the boiling temperature, 212°, be mixed with an equal quantity of water at the freezing temperature 32°, the result will be 2lbs at the medium temperature 122°. But if a pound of water at 212° be mixed with a pound of snow or crushed

will go on from ice, when surrounded by air at any temperature as low as Zero, and it is probable that it would do so at the lowest temperature at which it could be possible to try the experiment. Now if heat be the only, or even the principal agent in evaporation, as water is 860 times heavier than air at the sea level, how can ice acquire heat enough to render it buoyant and convert it into vapour, when under conditions that render it impossible that it can even obtain sufficient heat to convert it into water?

12. The great height to which vapour ascends, and at which clouds are suspended, seems also to shew that some other agent, besides heat, is in operation. The following table shews the density of the air and its temperature at different heights; the last column shewing the expansion necessary to render vapour buoyant at such heights:

Height.	Temperature of Air.	Density of Air.	Water heavier than Air.
5 miles	−25° Fah.	0·3163	2719 times
4 miles	− 8°	0·3981	2160 .....
3 miles	+ 9°	0·5011	1716 .....
2 miles	+26°	0·6309	1363 .....
1 mile	+43°	0·7943	1083 .....
Level of the sea	+60°	1·	860 .....
Barometer at the level of the sea 30 inches.			

Clouds have been seen as high as 5 miles: now at that height water is about 2700 times heavier than the air, and the temperature about 25° below Zero; how then is it possible that heat can be the cause of vapour rising to regions at so low a temperature? as vapour must be condensed long before reaching such heights: and how can heat be retained

---

ice, as near as may be of the temperature of 32°. 140 degrees of heat will be lost, absorbed, or become latent in the ice in melting, and the result will be 2lbs of water at the temperature of 52°, instead of 122°, as in the first case. Thus water is ice which has absorbed 140° of heat, or ice is water which has lost that quantity.

under such circumstances, so as to cause the suspension of water in a medium 2700 times lighter than itself?

13. On this head I have been answered that we do not know that clouds are really suspended, but that vapour may be carried up by currents of air, and the clouds, so produced, may be continually sinking, although very slowly from the extreme minuteness of the particles of condensed vapour. But we have the fact, that the Himalayas and all lofty mountains are covered with snow; therefore vapour is not only capable of being buoyed up to such heights, but also of being suspended there till wafted over many hundreds of miles. And it is this property of vapour by which that beautiful provision of nature is effected, which renders such mountains reservoirs of water for the supply of rivers during the heat of summer, and times of greatest need. I may also add, that Humboldt, Boussingault, Forbes, and other travellers, often make mention of meeting with heavy hail and snow storms when at great elevations in mountainous districts; which shews that the floating of vapour at such elevations is not a rare phenomenon.

14. Many other points might be advanced on this subject, and I believe I may fairly assert that it is impossible to account for the suspension of vapour and other meteorological phenomena, on the theory that evaporation is produced by the absorption of latent heat.

15. My own views on the cause of storms have been published in various forms during the last twenty years, and are perhaps known to some who are now present, but this I believe cannot be the case with the majority; and even to those who are acquainted with the theory I advance, there are points to which I am anxious to direct attention in reference to peculiar phenomena in this storm: I therefore beg to be excused if I seem to dwell too long in explaining my own opinions.

16. I believe that electricity is the principal agent in evaporation and all other meteorological phenomena. It is proved by Volta's experiment, and by the electricity of steam, that electricity passes off during evaporation. From a very early period in electric science, it has been known,

that to electrify a body promotes evaporation from it. And by some experiments of my own[b], which have since been verified by others, it is shewn, that to insulate a body retards evaporation from it. I may also add, that in almost every meteorological phenomenon electricity is more or less developed; and adopting the Franklinian theory, that electricity occupies space, coats the surface of all bodies, and has no weight, I believe that every meteorological phenomenon may be fairly explained by it.

17. I am aware that there is high authority for the opinion, that electricity is non-material and does not occupy space, and consequently, that it can have no buoyant power. But I believe there are fair grounds for the opinions I hold.

18. In the first place, a charge of electricity can only be given to a body when under atmospheric pressure. How can this be accounted for, unless from the pressure of the air preventing the passing off of the electricity? and if so, the electricity must be something that the air can press upon; consequently electricity must occupy space. A galvanic current that will only pass through a very small space of air under the ordinary atmospheric pressure, will pass through a considerable distance if that pressure be removed, that is through a vacuum tube. It is true that electricity will pass freely through metals, but this is no proof that it is not material and occupies no space; as the pores of metals may admit of free passage for electricity, and yet be impervious to the particles of air or water. It is certain that electricity cannot pass through air without displacing it; the slightest escape from a machine in action will produce a sort of fizzing noise, the passage of the smallest spark is accompanied by a snap, and to the effects of lightning in producing thunder I hardly need allude. Now no such effects as these are produced by the passage of light through the air, and the effect of heat in passing through air is simply that of expanding its particles. On these grounds I believe that electricity does occupy space, and from a consideration of such facts, together with the terrific effects of the lightning

[b] See *Phil. Mag.* Jan. 1842.

stroke, I am led to believe that the passage of electricity is that of something really material.

19. That the capacity of a body for electricity is in accordance with its surface and not to its mass, is, I believe, generally acknowledged; and that the capacity of vapour for electricity is in accordance with the extent of surface of its particles, is, in my opinion, proved by an experiment on the electricity of steam by Professor Faraday, who found that the same jet of steam, at the same time, exhibited three electric conditions. Near the mouth of the escape pipe it was negative, at a certain distance from the mouth it was neutral, and still further off the steam was in a positive condition. These facts seem to be explicable in this way. High pressure steam, on its first escape, expands enormously, during this expansion it is increasing its capacity for electricity, and any thing held in it is robbed of its electricity and brought into a negative condition. At a distance from the jet, where expansion ceases, the steam would be in a neutral state; still further off the steam would condense, the surface of its particles would contract, and they would thus become surcharged, and exhibit a positive condition.

20. It is also generally considered that electricity has no weight. I believe it may be quite independent of gravitation, but that it is impelled to the surface of bodies as other matter is towards the centre of the earth by gravitation; and that it is to the intense force with which electricity is impelled to distribute itself equally over the surface of all bodies, that its chief effects may be attributed.

21. It may be objected, that if electricity is quite independent of gravitation, it would rise from the earth and pass off into space, but this objection will not hold good; electricity can only exist in connection with some body, or while passing from some substance to another. It has been proved, by Beccaria and others, that the air cannot be electrified, all the electricity in the atmosphere being connected with its vapour or some other matter floating in it.

22. The theory I advance is grounded on these views, that electricity having no weight, occupying space, and coating the surface of all bodies—there must be some point at

which a body would be so small, that it would be rendered buoyant in air by its envelope of this imponderable matter. Thus if we suppose the surface of a large mass of metal to be coated with cork of the thickness of a thin sheet of paper, it would hardly affect the weight of it in water, but the metal might be reduced to such fine particles, that it would be freely buoyant in water if each particle were enveloped in a coating of cork as thick as that which enveloped the larger mass: and thus, if electricity has the properties I ascribe to it, it is obvious that particles of water, if sufficiently minute, would be rendered buoyant in the atmosphere by their coatings of electricity.

23. It may be asserted that I cannot prove that electricity has a buoyant power; this I grant is the case; but I can as positively assert that no known experiment can decide whether it has or not. It is one of those points that at present cannot be decided by absolute proofs, and therefore, considering this as an open question, I venture to submit my theory for your consideration.

24. The theory I propose is, that the atoms of water are so minute, that when completely separated from each other and fully enveloped in their natural coatings of electricity, they become so buoyant as to be liable to be carried away by slight currents of air, even when in their most condensed state; but if expanded by heat, their capacity for electricity being increased by their increase of surface, they are then rendered really buoyant, and are buoyed up into the air by their coatings of electricity; when, if condensed, they become positively electrified, and are still buoyed up by the electricity, till, on the escape of the surcharge, the particles fall as rain.

25. According to the general opinion, water or vapour becomes invisible by the absorption of latent heat, and is rendered visible by condensation. On the theory I propose, water, in evaporating at natural temperatures, undergoes no other change than the minute division of its atoms, and the expansion that water undergoes at such temperatures; the vaporous particles being rendered invisible by their being diffused, and becoming visible on their near approximation.

The evaporation of mercury may be referred to in support of this opinion, as no one can imagine that mercury is otherwise than in a metallic state when vapourised, and yet in that state it is as invisible as the vapour of water. The evaporation of both fluids being in fact strictly analogous[c].

26. Vapour on rising into the air, according to this theory, floats to that height to which its electric coating would render it buoyant; but although condensed, in accordance with the temperature of such height, it may still remain invisible. That vapour may form strata at various heights in the atmosphere, is shewn by the balloon experiments lately promoted by the British Association, (*see Phil. Trans.* 1853,) which prove that vapour is not distributed in the atmosphere as a gas, in accordance with generally received opinions, but that the air is in strata, or beds, more or less moist or dry at differing elevations. Now if vapour accumulates at any elevation so as to form a cloud, the sun shining on the cloud would cause evaporation from it, and the particles evaporating would rise from the cloud with a surface again expanded, *but coated with electricity in accordance with the surcharged state of the cloud;* they would consequently be buoyed up to a greater height than before, where another

---

[c] There may be properties in steam at high temperature with which I am not acquainted, but from what I know of it, I believe that steam at high pressure also does not assume the gaseous form. Its invisibility when under pressure, or at the moment of its escape, may be owing to the particles being so pressed as to form as it were one mass, and consequently producing one refraction only of the rays of light passing through them. As the particles slightly separate by contraction, from condensation or otherwise—they become visible from their various refractions; as ice or glass, however transparent it may be in the mass, becomes white and opaque when crushed up, although each separate particle would still remain as transparent as the piece from which it was broken. But as the vapour becomes still more diffused and *more condensed,* it again becomes invisible from the greater separation of the particles, rendering the refraction produced by one particle quite distinct and separate from that of all other particles.

cloud may form: thus the like process may be repeated again and again, and vapour be carried up to the greatest height it is ever known to attain. Clouds may therefore form at any, and every height, from the earth to the greatest height to which vapour can rise; and it is easy to conceive, not only the possibility, but the great probability that under favourable circumstances for producing them, and with such various currents as sometimes prevail in the air, clouds may at times be so arranged as to form a series of conductors from the higher clouds to the earth, and thus afford an escape for the surcharge of electricity from clouds floating at more than ordinary heights. This escape of electricity would enable the particles of vapour to form drops at a height far above that at which rain is usually produced; these, from the low temperature at such elevations, would be instantly frozen and form hailstones, which would increase in size by the accumulation of more particles of vapour during their fall.

27. Clouds of enormous depth are sometimes formed; these may result from the air being more than usually charged with vapour, or from the union of masses of vapour at different heights. Such clouds may be a mile or more in depth; and as, owing to the difference in the density of the air, it would require a much greater charge of electricity to render the particles of vapour buoyant in the upper part of the cloud than it would in the lower portion of it; and as, from the known laws of electric distribution, the electricity would equally diffuse itself throughout the whole mass of vapour; it follows, that all the vapour above the medium line would be deficient in buoyancy and press downwards, while all below that line would have a superabundance of electricity and press upwards, so that the particles of vapour in the middle of such a cloud might be pressed almost into contact.

28. With this view of the subject, a dense cloud may be considered as a mass of electricity interspersed with minute particles of water, the electricity being in proportion to the water at least as 860 to 1. In such a cloud, so long as the particles remain separate, no change of importance could

take place, as each particle would retain its coating of electricity, and be buoyed up by it; but the agglomeration of but a few particles into a drop of rain might be the commencement of a storm; for as the surface of the drop would be much less than that of the aggregate surfaces of the particles composing it, and as the drop could only retain a coating of electricity in proportion to its surface, it follows that the surplus electricity, consequent on the agglomeration of the particles, must instantly pass away, either by dispersion through the general mass of the cloud, or to the earth; consequently a vacuum would be created on the instant where the rain-drop formed, in accordance with the space occupied by the surplus electricity so dispersed; into this vacuum or rarefied space more vapour would be forced by the pressure of the atmosphere, more rain would be thus produced, and a further vacuum formed; and so a vacuum would be created and kept up in proportion to the fall of rain, and as long as it might continue.

29. It is impossible to say what is the real diameter of a particle of vapour or water; it may be the millionth of an inch, or less; but if we put it at the 200,000th of an inch, and consider a drop of rain as of the diameter of the 40th of an inch, it would take 125 thousand millions of such particles to make such a drop of rain. But the capacity for electricity of the rain-drop (that is, its surface) would only be equal to that of 25 millions of the particles, or the 5000th of the whole of the vapour of which it was formed; consequently, on the formation of such a drop of rain a proportional vacuum would be instantaneously created.

30. Now as water is 860 times heavier than air (12), every particle of vapour, when suspended in it, must occupy the space of an equal weight of air; therefore the fall of an inch of rain in an hour would produce a vacuum or rarefaction, equal to what would result from the loss of 33 millions of cubic feet of air per minute over every square mile; or of 639 cubic feet over every square yard where, and during the time in which, an inch of rain might fall. It follows therefore that all rains must produce a proportional rarefaction, but how far, even with heavy rain, a wind may re-

sult, or such wind would be felt, depends on the height of the cloud from which the rain may fall; for if at a great elevation, the wind might not be felt except in a moderate degree, and at a distance, as the effects where the rain falls may only be exhibited in a depression of the barometer; but if the rain-cloud be very low, then the wind might be felt in all its violence.

31. I have no doubt that the ascent of vapour into the atmosphere may, by displacing the air, cause a proportional flow of air *from* such parts; but I believe that every violent wind must be the result of an indraught to some parts, more or less distant, where the air has become rarefied; and the sinking of the barometer previous to and during storms seems to support this view. I cannot conceive the possibility of a current of air *violently* impelled, by an acquired momentum, through the general atmosphere, as the resistance to such a motion would be enormous. A current so produced must cause a considerable increase of atmospheric pressure and a rise of the barometer, whereas the effect of storms is the reverse, and generally in proportion to their violence.

32. Rain of a moderate character may produce winds proportional to the extent of the area over which they occur. Thus the equinoxial gales have the same general direction from west to east in spring, when the change of temperature in the quarter to which they blow is from cold to warmer, as they have in autumn, when the change of temperature is just the reverse; and it seems improbable that such opposite causes should produce the same effects. No such objection holds against the opinion that these gales are the effects of extensive rains in central Europe; in spring, after breaking up of the long and dry frosts of winter; and in autumn, after the hot and generally parching summer has passed.

33. I wish to be understood, as not doubting that changes of temperature do produce currents in the atmosphere, such as the trade winds, the land and sea breezes, &c.; and I have no doubt that winds are in some degree produced by changes of temperature in our own climate; but I believe the fall

of rain and escape of electricity from the clouds is the principal cause of our winds and of all violent storms; and it has been remarkable, that all the violent storms that have occurred during the last few months have been at times when very heavy rain has fallen in various parts of Great Britain or neighbouring parts of the continent.

The Storm.

34. I will now proceed to describe the storm; but before entering into the details of its various phenomena, I give the following graphic description from Mr. Smith's account, as affording a general idea of the storm and the devastation produced by it:—

"It occurred at about half-past one p.m. on Friday, December 30th, and beginning its devastations about a mile to the south of Calne, and coming up from the west, it shaped its course for E.N.E., and took nearly a straight line in that direction for about thirteen miles, its breadth varying from 250 to about 400 yards: at what velocity it rushed over this course it is impossible to conjecture, but it seems to be universally allowed that from two to three minutes was the time occupied in passing over any given spot; and during these few moments, it swept a clear and most perceptible path in its onward progress, tearing up by the roots and snapping short off the huge trunks of some of the largest elms and other trees, unroofing houses, stacks, and cottages, and hurling men and cattle to the ground, and dashing them furiously to and fro, and rolling them over and over in its rough embrace.

"Several persons saw it from a short distance, coming up over the open down, but being on one side of its course they were entirely out of it, and felt none of its breath as it tore by. Some of these witnesses describe it as a thick volume of smoke, or a dense cloud of steam rushing through the air: but to those within its line, so appalling was its appearance, and so terrific the roar of its approach, that the stoutest heart felt unnerved, and the steadiest head bewildered, at so sudden, so unusual, and so fearful a visitation. Most of the villagers sought refuge within their houses, apprehending

some unwonted catastrophe; while others who could not gain shelter in time, had to cling with all their might to posts or gates, and even so found great difficulty in withstanding the fury of the gale. In an instant the storm was upon them, ushered in by a most vivid flash of lightning and an instantaneous clap of thunder, and attended by abundant rain and hailstones of a large size. These, however, seem to have been partial in their favours, covering the ground in some places, while in others not one was to be seen. And so sudden and furious was its onset, so loud and deafening its roar, so strange and unearthly the darkness, (not unlike that attending the annular eclipse of the sun the previous year,) so terrific the crash of falling roofs, (tiles and rafters and thatch seeming to fill the air, while the windows were beaten in by the hail,) that many thought the Judgment Day had arrived, and others believed an earthquake was demolishing their homes. Indeed, so appalling was the whole scene, and in consequence men's senses seem to have been so paralysed with terror, that, (strange to say,) along the whole line of storm, where hundreds of trees were thrown down, scarcely a single individual saw or heard a tree fall, and nobody realized what was occurring till the hurricane had gone by. But in three minutes the storm had passed on, and then, when the frightened villagers emerged from their cottages, what a sight met the eye on all sides! the largest trees torn up by the roots, upheaving tons of earth attached to them to a height of fourteen feet above the ground, large branches snapped off and carried on many yards to where they fell; barns in ruins or prostrate on the ground; ricks demolished, and the sheaves carried away; their own houses unroofed, and their gardens filled with straw, fallen chimneys, and tiles; and all this havock effected in three minutes of time!

"Such is the general description of the storm, as I have gathered it from many eye-witnesses along its whole line, and from a personal and very minute inspection of its scene from end to end."

35. Although the storm was distinctly traceable over thir-

teen miles, its principal effects were within the first four miles. This portion of the track I carefully examined, as beyond that distance, the country being more open, the effects of the storm were less striking. The accompanying map of the track, from the point of its commencement to Yatesbury, will assist in a more detailed description of the storm; the arrows shewing the direction of the wind, as indicated by the fallen trees, &c.

36. The storm occurred (as stated above) about half-past one p.m. on the 30th day of December; that was eight days after the break up of the severe frost. For about five days before that of the storm, the weather had been very boisterous, and heavy rains, with lightning and thunder occurred in various parts of England.

37. At Oxford there was thunder and stormy weather on the 27th. The wind was very high on the 29th, its velocity averaging 22½ miles per hour, and on the 30th its average reached 25½ miles. The barometer on the 30th was pretty steady at about 29 and 3 tenths. The lowest range of the thermometer was 46 degrees, the highest 51, the average being 49 degrees on the 24 hours: a very extraordinary temperature for the 30th day of December. More than the third of an inch of rain fell at the Radcliffe Observatory in the 24 hours between 10 a.m. on the 30th, and the same hours on the 31st. The direction of the wind at Oxford was south-west and west-south-west the whole of the 29th and 30th. This was about the direction of the storm at Calne; *it seems therefore that the storm went in the general course of the wind blowing at the time.*

38. I give the particulars of the weather at Oxford, (as I could obtain no information on these points at Calne,) to shew, that about the time of the storm there was and had been a very general and strong south-west wind; the temperature was very even, but excessively high for the season; and the air heavily charged with moisture.

39. About Calne and its neighbourhood, the like weather prevailed. On the morning of the storm, there was a violent storm of rain, with lightning and thunder at Bristol. And

a like storm occurred at Chippenham. At Calne also there was *very* heavy rain, but it cleared up for about two hours before the storm came on.

40. The best and almost only account I could obtain as to the *first* coming on of the storm, was from Mr. J. Spencer of Bowood; who states, that the day was very bright and sunny, when all at once he noticed a sudden change had taken place: the sky, to the west, had a dense heavy aspect; not forming clouds, but as if the whole western part of the heavens was one dark haze, which very quickly became a dense mass. Before the sunlight was obscured, the sky was so black, and the air apparently so dense, that the trees, &c. stood out in extraordinary relief—as he had often noticed before, (though not to the same extent). He knew what was coming, and his men were closing up all the houses, &c., when a most terrific roar was heard, preceded by a breeze which had a remarkable hollow sound, and produced a chilliness through the system, like one feels when entering an ice-house in summer: this was the prelude to the storm. Next came down the hail, at first of an ordinary description, followed by the large pieces described in paragraph 79, and which are represented in the plates: these however did not fall very thickly. The hail *might last nearly a minute, when the rain* (which was tremendous for four or five minutes) *commenced,* preceded by lightning and thunder. He had no idea how fast the clouds passed, as he saw no clouds, the whole atmosphere being one dense mass of vapour. He heard the roar of the storm three or four minutes before the hail fell, it gradually increased till the thunder broke out, when he lost hearing it. The best idea he could give of the sensation produced by the roar was that of standing at the mouth of a railway tunnel when a train is coming through it; though even this hardly conveys the idea of the intense deafening roar which preceded the storm.

41. Bowood House, where Mr. Spencer was when the storm passed, is about half a mile north of the direct line of the track of the storm, and a little to the west of where it began its destructive effects. I am anxious that it should be noticed that the hail fell before the rain commenced. I

may also state that the peculiar roar which accompanied the storm was noticed by many persons. One man (who chanced to be a blacksmith) told me, in very characteristic language, that it was like a thousand forge fires in one.

42. I had a like description of the appearance as the storm came on from many who saw it from the level or low ground, that is, that it seemed like a dense mass of vapour or smoke rolling along the ground without any distinct form. The darkness produced by the passing of this storm-cloud was described as awful.

43. A gentleman from Oxford (F. Symonds, Esq.) who is a member of this Society, was out with the Duke of Beaufort's hounds when the storm came on. He also noticed the peculiar hazy appearance of the clouds; but said, the most remarkable point was their extreme lowness, as they seemed to sweep the ground. Mr. Symonds described the fall of rain as tremendous, although he was not directly within the track of the storm. He says it far exceeded any rain he ever met with, even within the tropics, and that to talk of being drenched with rain gives no idea of the thorough soaking he had, together with all others in the field.

44. The fall of rain along the track of the storm is described as enormous. Some said it was like a wall of water; one man told me that the water came down in *swashes*. On this head Mr. Smith says, "I regret that I have no means of ascertaining the precise amount of rain which fell during the hurricane, but that a very copious discharge then took place is certain; and by way of obtaining the nearest information on this head within my reach, I have instituted inquiries at all the mills near which it passed, and from one and all I derive the same reply, that the rise of the water was both greater and more sudden than was ever remembered on any former occasion of other heavy rains: this is the unanimous opinion of the millers at Cherhill, Quemerford, and Blackland Mills, where, though within a mile of the source of the stream which turned them, it was found necessary to draw the hatches and stop the works for a time, on account of the rush of water which bore down with irresistible fury immediately after the storm

had passed by." In reference to this fall of water, it should be borne in mind that the storm did not last more than a few minutes.

45. Although (as already stated) no distinct form of cloud could be seen from the lower grounds, I was informed by two persons, who saw the storm-cloud from the more elevated downs, that the higher portion of the cloud was very high, and seemed to lead or drag the lower portions along the ground. They said the lofty part had no apparent motion, except that it seemed to be rapidly sinking as it passed onward, but the lower seemed like volumes of smoke rolling over and over in *all* directions.

46. The first evidence we have of the destructive force of the storm, was its breaking a large branch off an oak tree, in a field on the west of the Devizes road, about a mile south of Calne. Thence (as shewn by the map) the storm passed over Stock Street Farm, the Rookery Farm, and Quemerford Villa, to Mr. Slade's mill; blowing down and breaking off many trees in its course, unthatching ricks, buildings, &c. By the time the storm reached Mr. Slade's mill, its violence seems to have increased considerably, as slated roofs were stripped, chimneys blown down, and so much mischief done, that when I saw the mill a short time after the storm it had a most desolate appearance, although many repairs had been made. "And now, (to quote Mr. Smith's account,) hurling down several trees on its way, it reached Blackland Park, (the seat of Mr. Marshall Hall,) hitherto renowned for its magnificent timber, and then the work of destruction began in earnest, all its previous efforts having been mere child's play compared to the fury of its attacks here. First it partially unroofed the new lodge, and snapped off many of the firs which formed a shelter at its back, then rushing forth into the Park, swept down no less than one hundred and forty-eight trees, some of great size and beauty, tearing up some by the roots, and snapping off other large trunks, as if they had been twigs; so that to the inmates of the house, who were looking from the windows, and who were slightly removed from the main line of the storm, it appeared as if all the

trees in the Park were simultaneously, and in an instant, dashed headlong to the earth."

47. From the commencement of the storm, till it reached Blackland Park, the wind seems to have blown direct; as the trees fell in the general direction of the storm track; but as it crossed the Park, the trees about the middle of the track fell with their heads inclined more and more towards the north, so that about opposite Blackland House the trees fell right across the road leading from Calne to Marlborough, forming an angle of about 80 degrees with those that fell near the House; that is, with the general direction of the storm. This seems to have been the most sudden and remarkable deviation of the wind from the general direction of the storm; but throughout the great part of the storm track, from this point, by far the greater portion of the fallen trees, that did not fall in the direct line of the storm, were inclined. more or less, towards the north. The following are Mr. Smith's remarks on this point: "I should explain here, that though there were occasional instances (two at Quemerford, one at Cherhill, and one at Yatesbury) of trees falling, as it were, *backwards*, with their heads turned towards *the west*, and many others in the direction of south and south-east, yet by far the more usual position of those which were not prostrated in the line of the storm was more or less northward, at every inclination, from right across to the general direction of the storm."

48. From the foregoing facts an opinion prevails that the storm "had a rotatory movement, spinning in circles, revolving very rapidly, and drawing every thing within reach into its vortex as it whirled along." That is, it was a cyclone on a small scale; and on a first view of the case there might appear fair grounds for such an opinion: but, as already stated (4.), I believe the effects of the storm could not have been produced by a wind blowing in circles or direct.

49. That out of so many hundreds of trees that were blown down, a few should fall backwards, (i. e. against the general course of the storm,) is, I believe, no proof of

a whirling of the storm; for had the wind really blown in circles, very many more of the trees must have fallen in that direction.

50. It is, I believe, certain, that the storm was not a violent current of air rushing onward into some rarefied space far ahead; but (however we may account for it) that it was a local disturbance of the air, produced and continued by the passing of the heavy rain-cloud, which was carried onward in a narrow track by the general wind prevailing at the time; and it is not difficult to conceive that in such a violent commotion of the air, eddies would be produced which might throw a few of the trees down against the general course of the storm; or even the various positions and strength of the roots might cause a tree while falling to swerve from the direction of a sudden force by which it might have been overthrown.

51. I believe the frequent inclination of the fallen trees to the northward of the direct line of the storm, may be accounted for on the theory I propose, i. e. that the storm was the result of a rarefaction produced by the fall of rain and escape of electricity from the clouds: for although, as there was a brisk general wind at the time, the rush of air into the rarefied space produced by the passing cloud must have been chiefly from its wake, still there must have been some lateral pressure of air into the space also: but if the rain was much heavier or more extensive on one side of the storm track than on the other, a rarefaction of the air would result on either side of the storm track from this fall of rain in proportion to the quantity and extent; therefore the lateral rush of air into the rarefied space produced by the passing cloud would be greatest from that side on which there might be the *least* rain.

52. Now (although with no absolute proof) I have reason for believing that the rain was *much* heavier on the north side of the storm track than to the southward of it; and thus the falling of so many trees with an inclination to the northward may be accounted for. In answer to my inquiries on this head, Mr. Spencer stated, that he had no information

as to how far south of the line of destruction the rain fell; but subsequently he informed me, that "from all he could collect, he thought the rain was heavier, and extended to a *much* wider distance from the centre line of the storm, on the north side of its track than to the south of it." A person, who was at Blackland Hollow (about half a mile from the storm track) when the storm passed, informed me that he felt nothing of the storm, and very little of the rain; so that he had no idea that anything extraordinary had occurred, till, on descending to Mr. Slade's mill, he found the road blocked up by fallen trees. Another person, who was out on the higher downs, about half a mile from the storm track, between Cherhill and Yatesbury, was quite out of the breath of the storm, and (I understand) had very little rain. From these statements it appears that the fall of rain was not heavy or extensive on the south of the storm track; whereas rain fell in torrents at Bowood House, which was half a mile, and hail and rain fell heavily at Calne, which was a mile to the north of it. Mr. Smith states, that "at Cherhill there was little or no hail, but that to the north, on the hill above, hail fell freely." Again, "at Monkton (where the storm passed over) no hail was seen, though there was abundance of rain; but at Berwick Bassett, within little more than half a mile of Monkton northward, the hailstones fell in large quantities, and of enormous size."

53. I may further remark, with reference to the direction of the fallen trees at Blackland Park, that the trees on Mr. Bodman's farm, (nearly opposite Blackland House,) which were blown down on the northern edge of the storm track, fell in the general direction of the storm. I give a rather enlarged sketch of this part of the storm track: the arrows shewing the position of the trees that were blown down; the crosses shew where trees stood that were injured only; and the round spots those that escaped injury altogether.

54. It was interesting to see the curious way in which the storm appeared to have selected its victims; as it did not make a clean sweep of all in its course, but took the

trees here and there in a most singular manner; trees of great size being blown down or broken off, while others standing close by, and quite as exposed, were not injured in the least. This was observable in many cases in Blackland Park, but more strikingly so in Hail Farm rookery. It seemed as if not only the rain came in *swashes*, but that the wind did also. The effects of the storm on a pollard oak in Mr. Bodman's field (marked A in the sketch) was very remarkable. It stood near the northern limit of the storm track, and the half of its branches, towards the south, were *crushed down* as if from some enormous weight passing along in the direction of the storm, while the other half of its branches were uninjured.

55. After the storm passed Blackland House, trees were here and there blown down along the southern portion of its track, these mostly falling in the general direction of the storm. But along the northern portion of its track the storm lulled in a great degree, as from Mr. Bodman's fields to Hail Farm scarcely a mark was left of its violence. The cottages called the Waggon and Horses were uninjured, although nearly in the central line of the storm. Such a lull in the violence of the storm might be produced by a diminution in the fall of rain over that spot, and the occupier of one of the cottages stated, that when the storm passed over, the rain did not seem heavier than he had often seen.

56. On reaching Hail Farm, (in the occupation of Mr. Lewin Arnold,) the storm was again very violent, doing great mischief to the ricks, buildings, &c., and blowing down or breaking off nearly all the fine trees forming the rookery in the field adjoining. I give an enlarged sketch of the farm and field, the arrows shewing the position of the tress that were blown down; the arrows with a cross line shew the situation of trees that were broken off at some height from the ground, and the direction in which the tops were blown; the crosses shew where trees stood that were injured but not broken off; and the round dots shew the situation of the trees that were not injured. From an examination of the trees on the spot, and consideration of the subject since, I cannot conceive this wholesale destruction to

have been the result of a whirlwind. None of the branches seem twisted, nor were any of the heads of the trees thrown together, as must have been the case had the wind revolved in small circles; and the narrowness of the storm-track shews that it could not have been a whirlwind on a large scale. I believe all to have resulted from the rush of tumultuous torrents of air into the rarefied space produced by the passing storm-cloud. In the six trees that were broken off, the heads being carried towards the south-east, we have the first evidence of a lateral rush of air from the northward into the storm-track.

57. From Hail Farm the storm passed over Mr. Maundrell's house, (Labour-in-vain Farm,) and, amongst other mischief there done, broke off about 40 trees. A fir tree, of between 6 and 7 inches in diameter, was broken off, *and carried to the distance of* 333 *yards*, in a direction a little north of the direct course of the storm. The tree must have been carried through the air to that distance, as it left no trail whatever across the field, which was of young springing corn.

58. Between Mr. Maundrell's farm and Cherhill mill, there is a narrow strip of land of little more than half an acre in extent, called the Butt, being about the centre of the storm-track, and directly in the line of its course. Elm trees were growing along both sides of it, 23 of which (nearly the whole) were dashed down as the storm passed along, those on the south side falling, some in the direction of the storm, but the greater part more or less inclined across its course towards the north; while all those along the north side, except one, fell in the direction of the storm-track, or inclined across it towards the south, shewing that the air swept in from both sides as well as in the wake towards the rarefied space produced as the cloud passed on.

59. As we approach Cherhill the ground rises pretty rapidly, the valley, along which the storm passed, contracting at Cherhill Mill to a narrow gully, which runs thence to about 300 or 400 yards beyond the church; this gully being the source of the small rivulet that drives the mill. I fear I should fail if I attempted to convey an

idea of the devastation from the storm at this point, and therefore again quote Mr. Smith's account of it. "Here it seems to have contracted its breadth, and to have rushed up the gully, along which the greater part of the village of Cherhill is built, and here, confined within narrower limits, its fury seems to have been poured upon every thing which came in its way, so that scarcely a tree stands unscathed, while hundreds are lying in every direction, and scarcely a cottage retains its roof, the thatch and tiles, and in some cases chimneys, falling victims to its attacks. A few of the most prominent particulars in this locality may exemplify its violence: and first, Cherhill Mill deserves especial mention, no less than fifty trees (half of them elms, and the remaining half apple and other fruit trees) having been thrown down within a very small space; and yet Mr. Reynolds the miller (who in passing to the mill could not reach it before the storm was upon him, and clung to a rail of the orchard during its entire passage) assures me that he neither heard nor saw a single tree fall, so awful and bewildering was the effect of its sudden tremendous and deafening attack. Again, in another instance, the roof of a cottage was lifted off in a mass and deposited in the road; while both the Church and the School sustained injury, though not to a considerable amount. Throughout this village again the property of Mr. Heneage suffered severely, more especially in the farm occupied by Mr. Neate, where the roofs of the farm buildings and barns were all more or less injured, in addition to the loss of many magnificent elms and other trees, to the number of about thirty-five overthrown or dismantled. And again, the farm of Mr. Hanks sustained considerable damage to the roofs of the house and outbuildings, as well as to the barn, stack-yard and the trees which sheltered them."

60. In no part of the storm-track did there appear to have been such a wild commotion of the winds as at Cherhill Mill, as the air must have dashed down with tremendous force from the higher ground on the southward, the fruit trees appearing as if they had been crushed rather than blown down, and the elms in the bottom were lying in great

confusion, but with their heads more or less to the northward, some two or three lying to the northwest, therefore inclined somewhat backwards in the course of the storm. It seemed as if the wind had recoiled from the steep bank to the north of the gully. Again, from the top of a cottage situate a little S. W. of Cherhill Mill, "a slate ridge-crest weighing 27½ lbs, and measuring 4½ feet long by 7 inches wide, was carried northward about 40 yards." But while we have such evidence of a rush of wind from the southern, we have also evidence of a violent current from the northern side of the storm-track, shewing that the wind set in on both sides toward the central line along which the storm passed; as at Oar, or Whir Farm, 7 trees were blown down, all with their heads toward the Mill, although not more than about 300 yards from it; and a corn rick was in great part blown away in the direction indicated in the map.

61. It was remarkable, in many cases, that houses and other buildings standing right across the direct course of the storm, had the slates or thatch taken off on the lea side of the roof, while the side fully exposed to the coming on of the storm was uninjured. Slates were blown from the roofs of outhouses, &c., although attached to the lea side of much more lofty buildings, or otherwise sheltered from the *direct* force of the storm. These effects could, I believe, only have been produced by the expansive force of the air within the buildings, as the air above them became rarefied by the passing of the storm-cloud; and it is easy to conceive that the rarefaction must be most complete on the leaward of any object that prevented the onward rush of air in the wake of the storm. Thus roofs might burst outward from the expansion of the air beneath them as the storm-cloud passed over, while such an occurrence would be prevented on the windward side, by the pressure of the air rushing forward into the rarefied space in the cloud itself.

62. At Mr. Slade's mill, and other places, I noticed effects that could not (I believe) be accounted for otherwise than as I suggest, and at Cherhill Mill two cases were very remarkable. The mill stands right across the course of the storm, and during the storm, as already noticed, the rush of

air down upon it from the southward must have been very violent; yet several bricks from the apex of the gable end *facing the south*, that is, those directly under the ridge of the slates *were blown outwards*. Again, at the back of the mill, that is, on the east side of it, there is a bakehouse with a long sloping roof, the highest part of which is considerably below the eaves of the mill; it was covered with very close fitting tiles, the rafters being lathed and plastered on the under side. Very many of the tiles were driven off this roof during the storm; not beginning at the edge, as if from the immediate effect of wind, but here and there from several parts of it. Now it was impossible that the wind could have acted on the tiles from beneath, as the plastering was uninjured, and I believe the tiles were blown off by the expansion of the air confined between them and the plaster.

63. On the higher part of Cherhill, many tiles were driven off the leaside of the roof of a house, while the roof on the side which faced the storm was uninjured. It was not noticed that the tiles were off till after the storm had passed, and Mr. J. Rawlins (the occupier) thought they were driven off from the front door being blown open during the storm, and the wind rushing up the staircase and through the trap door under the roof. Had this been the only case of the kind, I should not have dwelt upon it, but from all I saw, I have no doubt that the cause I assign is the most correct. I mention this case particularly, as the house stands by the road side, and being rather more lofty than those near it, the circumstance of the tiles being blown off on the one side only was noticed by many who visited the track of the storm.

64. One extraordinary effect of the storm, which Mr. Smith considers as its *greatest feat*, "was the breaking off, and hurling to a distance of nearly 60 yards before they struck upon the soft ground, the heavy tops of three elm trees, standing just above Cherhill Mill, whose length was about 25 feet, and whose weight may be conjectured from the fact, that Mr. Reynolds assures me it required three horses, and even then was as much as they could do, to drag them one by one into his yard." These trees stood on *rising*

ground immediately above the mill at the mouth and on the north face of the gully.

65. The village of Cherhill stands on the south side of the glen, and on this side, as far as from the mill to near the church, the ground rises gradually towards the south, while the bank on the northern side is very steep, forming in places quite a cliff. From the back of Mr. Neat's house and the church the bank is steep on *both sides*, but much the highest on the northern. The violence of the storm (as already described) was tremendous on the southern side, and especially along the bottom, which seemed to be the centre of the storm. The trees blown down on the higher ground near the turnpike road fell in the general direction of the storm, while most of those on the lower ground, and along the glen, fell with an inclination more or less towards the north; but the trees growing on the steep northern bank almost entirely escaped; the only injured tree I saw was pointed out to me by Mr. Neat, being a small one which grew near the bottom of the high bank near the church, and was snapped off a few feet from the ground. These facts seem to prove, that the inclination of the fallen trees across the line of the storm towards the north, was caused by a lateral rush of air from the southward *into* the wake of the storm-cloud, and not from the wind whirling in circles from south to north. Again, on *the very verge* of the northern bank, three or four moderate sized Scotch firs were growing; these, from their dense foliage, must have been more liable to injury from the wind than the leafless trees, and yet they seemed uninjured; this I believe could not have been the case had the wind whirled from the south across the glen, instead of blowing down into it.

66. The northern side of the glen is a large open field, with no trees, or any thing on which the storm could leave a trace of its course, except two hayricks belonging to Mr. Neat, and these were, in great part, blown away in the direction indicated on the map, shewing that there also the wind from the northward was inclined toward the central line of the storm track.

67. In the open and most exposed fields, none of the hedges or low bushes over which the storm passed seemed in the least injured. But at the eastern end of Cherhill churchyard there is a very steep bank down to the bottom of the glen, and right across the direct line of the storm; the small trees and shrubs which grew upon it were apparently protected from the storm, as only the tops of a few of them were higher than the bank, and many were quite below that level; and in addition to this, there was a rick standing on the edge of the bank and broadside to the storm, "yet the trees on the bank were crushed down as by an avalanche." When I saw the bank, many of the trees and bushes were still attached by their roots with their heads hanging downwards. This phenomenon can only be accounted for as produced by the rarefaction of the air in the glen as the storm-cloud passed, and the rush of heavier air down the bank into the rarefied space.

68. On the more open and *rising* ground between Cherhill and Yatesbury, there was very little to shew the power of the storm. A corn-rick was standing in the narrow but deep track which runs *up* the hill, being a continuation of the gully from Cherhill; this rick was in great part swept away by the storm, which hurled whole sheaves several hundred yards, and carried large quantities of straw up, or rather over the hill as far as Yatesbury, a distance of more than a mile, shewing that a strong upward current prevailed where the storm passed over rising ground. Six trees were standing on the higher ground, five of which were thrown down in the general direction of the storm, the other had its branches torn off, and formed for a time a very conspicuous landmark as to the course the storm passed over.

69. Passing over the high table land or plateau of the open downs, the storm "dashed towards Yatesbury, which was to be the principal scene of its triumph. And first, singling out here and there a fir tree in some long plantations and belts on my glebe, it snapped them off or tore them up, to the number of forty, with most fantastic partiality, as if sending out a whiff for the purpose, as the main body of the storm hurried by, and leaving the sur-

rounding trees apparently unruffled by the breeze. Thence, abstaining from the slightest injury to the church, and scarcely removing a tile from the school, it began a furious onslaught on the timber all around, uprooting one of the large yews on my glebe, but sparing the pride of our churchyard, (which without partiality I believe to be the finest and best-grown yew-tree in the county,) and overturning right and left, on either side of the church, the large trees on the property of Mr. Charles Tanner, which were the ornament of that portion of the parish. Then straight away for Mr. John Tanner's and the south-end of the village, where it did more damage than in any other spot in its whole course: for, first, it entirely unroofed several cottages, ricks and barns; then threw down chimneys and outhouses: lifted off in a mass the entire roof of a long cattle-shed, which was in a measure protected on the windward side by a large barn at no great distance from it; smashed in the windows on the south front of the house; laid flat the east and west walls of the kitchen garden: prostrated two barns, and uprooted or broke off almost all the fine elms round the house; in addition to the playful freaks of throwing a cow into a pond, hurling one of the large cart horses from one end of the yard to the other, and dashing him at length against the shed at the extreme end; and as a climax, taking up a heavy broad-wheeled waggon weighing 22 cwt., and lifting it over a high hedge, depositing it on its side a dozen yards or more from where it stood." Thus Mr. Smith describes the effects of the storm in his own village; but I believe no description could convey an idea of the destructive effects of the storm at this place, especially on the premises of Mr. J. Tanner: nothing but a survey of the ruins at the time could have been sufficient to do so.

70. Several of the effects of the storm at Yatesbury are particularly interesting, not only as shewing the power of the storm, but more especially with respect to the light they throw on the cause of storms.

71. In reference to the proof, afforded by the direction of the fallen trees, of currents from both sides towards a

central line, Mr. Smith, after mentioning the case of the trees in the Butt (58), states that "at Cherhill several large elms on Mr. Neat's land fell across one another in diametrically opposite directions: precisely the same thing occurred with reference to his own trees in the long plantation; the firs in more than one instance fell with their tops towards one another, and in one case actually crossing each other on the ground. And again, in a field to the west of the churchyard at Yatesbury, a row of elms and a row of ash, in parallel lines, and of sufficient size to have served for years as the favourite nesting places in a thriving rookery, have been uprooted, *both lines falling inwards, across the direction of the storm, and towards one another.* These elms, eight in number, and each measuring 70 feet in length, were all thrown down without an exception; of the ash (which measured 60 feet in length), three only of the row of nine were prostrated; the rows of elms and ash were about 60 yards apart. In the field east of the churchyard two large elms were blown down towards S.E.; and four N.N.W.; these also were 60 yards apart: between these two fields stand the church and churchyard, which were uninjured." *

72. The fact that the two walls of Mr. Tanner's garden both fell inwards, towards each other, may be advanced

---

* No effect of the storm, which came under my own observation, left a stronger impression as to its power than its throwing down these 8 trees. They were, to all appearance, fine healthy trees, standing apart, but right across the field, with no ditch or anything that could render them more liable to injury from one quarter more than another. They must have withstood the storms of many years and all seasons; and yet, although leafless, in one moment the whole were dashed to the ground by the aërial torrent that swept over them. There were no twisted branches, nor were the heads of the trees thrown towards each other, as if from the effects of a whirlwind, but the whole of the row were prostrated, as near as the eye could judge, in one direction, with their heads towards the ash trees that fell towards them.

as a proof of the pressure of the air from without into the rarefied space produced by the passing storm-cloud.

73. The cattle-shed, off which the roof was lifted by the storm, formed with other buildings an inclosed yard; the shed had a brick back and ends, being open towards the west: it was, I believe, about the lowest building in the yard, and not more than half the height of a large barn which formed the opposite side of the yard, 55 yards' distance from the shed, and *directly to the windward of it*. The roof of the shed was strongly timbered, and covered with blue slates. I have had an estimate of the weight of such a roof from two architects well acquainted with farm buildings, and both gave the weight as 4 tons. It is impossible to say what the real weight may have been, but half a ton more or less is of little consequence in considering such a subject. However, be its weight what it may, the roof was lifted right off the walls, and deposited on the ground in the garden behind, as if it had been placed there by machinery. Many of the slates were shaken off, but not a single brick of the walls seemed to have been disturbed. Now I believe that no *direct* wind could have lifted the roof in this manner, leaving the walls uninjured; and, in addition to this, the shed was protected from the direct force of the storm by the more lofty building to the windward, which would seem to render such an effect impossible. That it was not the result of a whirlwind is evident, as the roof was left on the ground, in a position parallel to that it had occupied on the walls. I believe the roof was lifted from the walls by the expansion of the air beneath as the storm-cloud passed over, and was then carried forward into the garden by the onward rush of air in the wake of the cloud: for, as before stated, it is easy to conceive that the rarefaction must have been most complete to the leeward of any object that prevented the onward rush of air in the wake of the storm. Now the shed was not only protected in front from the direct rush of the storm, but also on the sides by the other buildings. Under such circumstances the rarefaction may have been intense, and produced the effects I attribute to it.

74. The fact that the waggon was carried over the hedge during the storm, can, I believe, only be accounted for as from a like cause, i. e. that it was thrown upward by the expansion of the air beneath it, owing to the rarefaction above as the storm-cloud passed, and was then carried over the hedge by the onward rush of the storm. The waggon was standing alongside of the hedge, directly across the course of the storm, and was taken right over the hedge, and deposited about a dozen yards from where it stood. As the waggon had stood in the same place for some time, an impression was left by the wheels, shewing that it was only 9 feet from the centre of the hedge, which was not less than 12 feet high; and from measurements by Mr. Smith and myself, I believe the waggon to have gone more than 8 feet in height, or the branches *must have been broken;* and as not even a sprig of the hedge seemed to be injured, it is probable that the waggon was at a still greater height when it passed over it. It is evident, therefore, that to pass over at such a height, from a distance of only 9 feet, it must have been tossed nearly upright, and then carried onward by the direct force of the storm. From the situation of the waggon, after the storm, it did not appear to have been whirled as if taken over by a whirlwind; and a direct wind would have driven the waggon through the hedge, and not over it. The weight of the waggon was 22 cwt., and as there was a quantity of hay in it, the weight may be put at 23 cwt., that is, 2576 lbs.: the dimensions of the bed of the waggon was 11 feet by 6 feet, so that the surface on which the air could act, to throw the waggon upwards, was 66 square feet, (exclusive of the wheels, &c. on which the air could have very little, if any, lifting power). It would, therefore, have required a pressure of more than 39 lbs. to the square foot to have moved the waggon in the least, and it must have been a much greater pressure to throw the waggon up so as to clear the hedge. Now a wind with a pressure of 39 or 40 lbs. to the foot is a *very rare* occurrence in this climate; but even if we allow that the wind at the time did blow with such a force, (as in all probability it did) what could cause it to exert this force perpendicular

to the underside of the waggon so as to toss it upwards? The hedge was not an obstacle that could cause a recoil of the wind, for although it was high and its branches stout, yet (like most old hedges) it was not thick, so as to be much obstruction to the wind. Looking at the case how I will, I can see no other assignable cause than the one I suggest, that is, the sudden expansion of the air beneath the waggon as the storm-cloud passed, and it appears to me that such an event may occur. It cannot be thought that a complete vacuum could have been produced over the waggon, or the pressure from below in such a case might be equal to 63 tons; but if the rarefaction was equal to one-twentieth part, that would have been more than sufficient to produce such an effect, or even one-fortieth part would give a pressure of 53 lbs. to the foot.*

---

* The following extracts from a letter in the "Times" of Feb. 23, 1860, from E. J. Lowe, Esq., dated Observatory, Beeston, Feb. 19th, will shew the violence of a wind of 20 lbs. pressure to the foot, and assist the formation of an idea as to what a pressure of 40 lbs. must be. It may also be worthy of remark, that there is a striking resemblance between the hurricane here described, and the storm under discussion; as in both cases clouds with rain and hail rolled in waves along the ground, and both storms were of short duration. I hardly need state, that Mr. Lowe is, and has been for many years, one of the most accurate and assiduous observers of meteorological phenomena of the present day:—"A great gale has been raging here to-day, the force of which from 2 p.m. till 2.5 p.m. was greater than I have before registered, viz. 20 lbs. pressure on the square foot. In this short time it did considerable damage to my instruments, and to shew its violence, I may also mention that I myself was carried across the Observatory by the wind, and thrown with much violence against a wall."

"Exactly at 2 p.m. clouds of rain and hail rolled in waves along the ground, and the air became very dark; suddenly a hurricane commenced, which fortunately only lasted five minutes: during this short time a pressure of 20 lb. on the square foot was maintained, the force being greater than I had ever before registered."

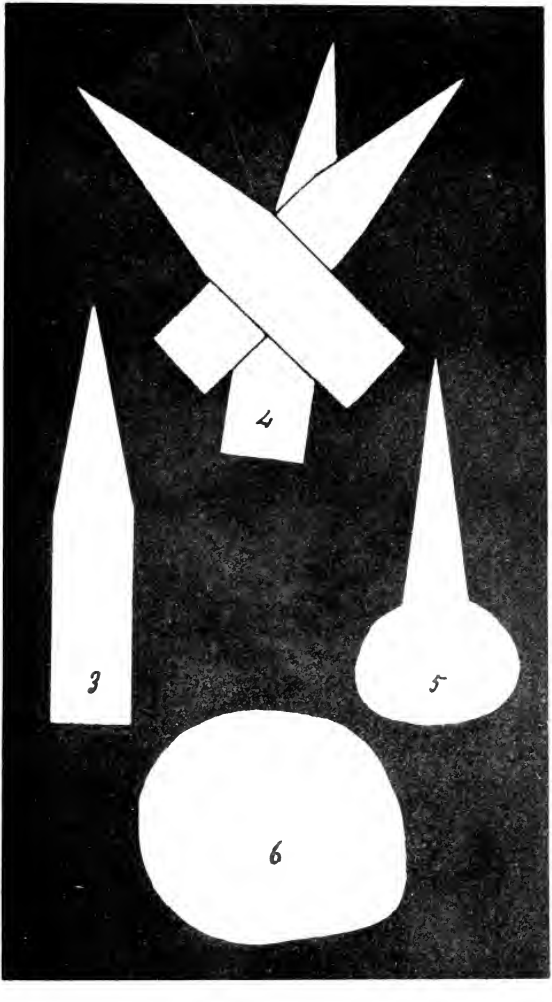
75. Leaving Yatesbury, the storm passed on to Winterbourn Monkton, about two miles distant, overthrowing the few trees in its way. There it was again very violent, especially on the farm of Mr. Eyles, "throwing down the barn, an excellent one, of great strength, and in good repair; seizing the heavy, substantial roof of a long and perfectly new cattle-shed, (measuring 53 feet by 16,) *and lifting it off the walls which supported it in a solid mass;* snapping off the fir trees, and uprooting a vast number of elms. The church was considerably damaged; the school too lost its bell turret, and was otherwise maltreated; the old rectory-house became a ruin, and many ricks, sheds, and other buildings in the village were unroofed." These particulars I learn from Mr. Smith's account, as my examination of the storm-track did not extend further than Yatesbury. I have since seen the roof of the cattle-shed, but it was then replaced. It is a stout, well-timbered, thatched roof; I can form no idea of its weight, but it must be considerable. The removal of this roof also I believe to have been from the expansion of the air beneath it; it was not lifted right off and clear of the walls, like that at Mr. Tanner's farm, but was moved so as to be resting partly off the walls 6 or 7 feet from its former position, and yet the walls were not injured: shewing that it must have been upheaved from the walls, and then have fallen on them again very steadily, or they would probably have been broken down by such a weight. It may also be worthy of notice, that, although the storm was so violent, the thatch of this roof *was scarcely if at all damaged.*

76. From Monkton "the storm once more began to mount, and this time to the highest down, even to the summit of old Hackpen. Here as it hurried by the cottages and barns on the bleak hill-top, that rejoice in the wonderful name of 'Glory Ann,' (as may be seen in the Ordnance and other maps,) it seems to have had a friendly feeling towards buildings so exposed and solitary, and merely giving a passing salute by scattering a little thatch here and there, down it rushed to Temple Farm, in the occupation of Mr. Kemm, where it overturned several trees,

and tore off the thatch of barns and other buildings. Thence up again to the heights above Rockley, and uprooting a few trees there with its accustomed eccentric partiality, away over the open country, and down into the valleys, and up again over the intervening downs to Ogbourne St. George, where it left its last parting token, by blowing down a small barn and two trees. From this point we lose all trace of it, and we may conclude it did no further damage, but had ended its career; for though many reports have been circulated of its effects farther on and in several localities, they all appear on investigation to have been the result of other gales, which were very prevalent all over the kingdom at that time, but to have had no connection with this."

77. I have now described the whole course of the storm and its most extraordinary effects: there are other points to which I will call attention, and perhaps the most striking is the fact, that though the storm passed "through three villages in its course; though it occurred in the very middle of the day; and though it extended for no less than eleven miles in length by nearly a quarter of a mile in breadth; and though hundreds of trees were in an instant thrown down, across the roads, and over the gardens, and in several cases upon the cottages themselves, yet most mercifully not a single life was lost, nor did any serious accident occur to either man or beast, although some few hares and partridges were picked up dead after the storm."

78. The hailstones which fell during the storm were in some places of very extraordinary forms. A woman said she picked up a plate full, which she described as being of different shapes, such as spears, crosses, and cog-wheels; one she said was like a little child. A shepherd described some to Mr. Smith as like the middle of a waggon-wheel with the spokes broken off. I mention these cases to show that the hail must have been of an extraordinary character to attract the attention of persons who are not often observers on such subjects, and also to shew how quaintly extraordinary phenomena may be described. However we have the evidence of persons well qualified to describe such


4
3
5
6

phenomena; the figures in the plates shewing the form and actual size of hailstones that fell and were measured during the storm. In many cases it has been stated, that during violent storms pieces of ice have fallen, as if water had frozen into *sheets* in the air, and then broken up into angular pieces, or been smashed up on reaching the ground. It is probable that the fall of hail similar to that in this storm may have given rise to such statements.

79. The figures 1 to 4 represents the larger hailstones that fell at Bowood (40), Mr. Spencer measuring some of them at the time of the fall. No. 1 and 2 represents flat pieces of ice of a star-like form, of nearly half an inch in thickness, with from 4 to 7 obtuse rays, but the rays differing very much in size: they had a decidedly crystalline form, but were slightly encrusted with frozen vapour. No. 3 shews another form which fell sometimes singly, and sometimes two, three, or four were frozen together irregularly, as represented by No. 4. I may again repeat, that these represent the actual size.

80. These hailstones fell clear of the rain-cloud, and although slightly encrusted with frozen vapour, may be considered as retaining the forms first taken by them when high in the air. They were of a crystalline form, not differing so much as snow crystals differ, or the forms water will assume when freezing. Now I submit that the formation of such hailstones as these cannot be accounted for on the theory proposed by Mr. Espy (8) as such crystalline forms could not have been produced in the strong currents necessary for the production of hail according to that theory. How far my own views on the subject (26) may be adopted I know not. No. 5 represents the size and forms of some that fell on the grass-plot of the vicarage-house, Calne. In this case it was raining heavily, and it seems as if this form was the result of hailstones of the form of No. 3 falling through the lower or rain-cloud, and becoming increased in size by the accumulation of vapour frozen on the larger and heavier ends. "At Yatesbury again, the hailstones were of an entirely different shape, for they had now lost their wedge-like character, and resembled rough irregular stones of

about two inches in diameter, No. 6: this form may perhaps have been produced by their being whirled about and retarded in their fall, when the storm was at its greatest violence." Hailstones similar to those at Bowood fell in the hunting field, cutting the hands of those who had no gloves on, but they were not so distinct in form, probably from the heavy rain which fell also. At Berwick Basset hailstones fell measuring 6 inches in circumference, and half an inch in their smaller diameter.

81. The last point connected with the storm, to which I have to call attention, is, that although very vivid lightning with heavy thunder accompanied the storm throughout, not the slightest damage occurred from it. Mr. Symonds informed me, (and I had similar accounts from three other gentlemen who were in the hunting field,) that it appeared as if they were surrounded by electricity, which seemed to come down in floods, and was perceptible both to *taste* and *smell*. These facts strongly support the opinions advanced in my *Essay on the Cause of Rain**: that "Although lightning is probably *at all times* accompanied by or instantaneously followed by a heavy dash of rain, whenever it strikes from a cloud to the earth, still I believe that during *excessive* rains the electricity which passes off to the earth in the form of lightning, is trifling when compared with what is conducted from the clouds by the falling torrents of water. And although lightning is generally most dangerous when the rain is heavy, yet that during *very excessive rains* the danger from lightning is comparatively little, the electricity passing off to the earth in a wholesale manner, being conducted imperceptibly by the falling torrents of water."

82. On the 22d of September, 1856, a storm which commenced at Glastonbury was very destructive in many parts of its track from thence to about four miles N.E. of Oxford. In its phenomena it much resembled the late storm, except that it extended over a greater space, and that it was still more capricious in its destructive attacks which were only here and there. A similar roar accompanied both storms

* See advertisement at the end.

(40). As a gentleman informed me, that when about two hundred yards from the Glastonbury Railway Station, to which he was going to meet a friend, "he heard a noise which he supposed to be the train approaching, *though it sounded unusually loud;* he was so impressed with this notion that he hurried on in order not to be too late, and so saw nothing of the storm, though it must have passed quite close. At Clyffe Pypard also, the peculiar howling of the wind was noticed. And at Buckland the wind was described as making a terrific roar which was heard two minutes before the storm came on. This peculiar roar, which has been noticed during violent storms, may, I believe, be fairly attributed to the rush of air into the rarefied space within the clouds.

83. The clouds also in this storm were very low, and seemed to sweep the ground. When speaking on the subject to a working man who was out in the storm as it passed near Oxford, I received the following expressive answer:— "They (the clouds) seemed right bang down as if you couldn't get under them;" and respecting the rain he said, "It didn't rain at all, but came down any how."

84. In the Glastonbury storm it was remarkable that its *chief effect was in hollows, the highest ground generally escaping;* and there were many cases that gave evidence of a current acting upwards with great force; and in others a like evidence of a downward crushing effect. In one instance, when passing a hill near Glastonbury, "on the side which faced the storm it evidently rose, *taking off the tops of two elms*, and all but clearing the rest of the hill. On the other side it descended again, and swept down towards the lowlands between Glastonbury and the Mendips; here the grass looked as if a strong stream of clear water had passed over it." At Clyffe Pypard the storm was very violent. "This place is situate immediately under a steep hill, which is to the south of it, the storm coming on from the S.S.W. The first effects appeared a few hundred yards above the hill, where several large trees were blown down or broken off: it then swept down a fir plantation on the side of the hill, snapping off or tearing up 70 trees of 50 years' growth,

and breaking *and crushing in a singular manner* (as if from a heavy fall of snow) the heads of many large beech, oak, and ash in the copse adjoining." "At Elsfield, which, being situate on a hill and *facing* the storm, was fully exposed to its fury, within a small space six or seven large trees were blown down or broken off; *the top of a large elm was blown off, and carried over a wall some* 10 *yards or so* into a garden, and there stuck upright as if planted. These effects give evidence of a strong upward current, as the higher trees only were injured; the shrubs and lower plants escaping."

85. Similar phenomena to the above were exhibited in the late storm. It did not exert its very destructive fury till it reached the low lands at Mr. Slade's mill and Blackland Park. At Cherhill the crushing downward effects were shewn on the trees in the bottom near the mill and along the narrow gully through Cherhill, while the upward sweep of the current on rising ground was shewn by the tops of Mr. Reynolds' trees being taken off and carried so far, and part of Mr. Neat's corn-rick being carried over the hill to Yatesbury. There was very little to mark the power of the storm on the high land between Cherhill and Yatesbury, and from thence to Mr. Tanner's farm, it is rather down hill, Monkton also lies low, and so does Temple farm, at all which places the storm was destructive, while the exposed cottages at "Glory Ann" on the highest part of the downs almost escaped.

86. The Glastonbury storm was described as a whirlwind, but I could obtain no direct evidence to shew that it was, and in fact all seemed to me to shew that it was not so, as near Glastonbury, out of many trees examined, "most of them were thrown down in the direction of the storm—some sideways, both right and left, and only one backwards;" and the like seems to have been the case throughout its whole course.

87. There are other points of resemblance between the two storms, but I believe I have stated enough to shew that both may be fairly considered as produced by similar causes. I have been anxious to shew this, from the Glastonbury

storm having passed *nearly over* the Radcliffe Observatory at Oxford, most important data being thus afforded, by the effects of the storm on the meteorological instruments at the observatory, variations in the instruments being self-registering by the aid of photography. The barometer had been sinking gradually the whole day previous, the photograph shewing a regular and tolerably straight line till the passing of the storm, when it suddenly sank, shewing a diminution in pressure of seven hundredths of an inch, and then it more suddenly rose again to its former level. The anemometer shews that for some hours previous to the storm the wind was blowing briskly, but from about half an hour before it commenced the wind rather lulled. The first gush of the storm blew out the gaslight connected with this instrument, which fortunately was discovered within five or six minutes; there is therefore a blank in the photograph for the interval; but it is evident that the wind during that time increased in a very violent degree. After the storm had passed, the wind sank to about the same rate as previous to the half hour before the storm.

There was no change in the direction of the wind during the storm; and *the thermometers were not affected by it.*

The photograph of the raingauge being taken by the same light as that of the anemometer, there was a like blank for the five or six minutes; but it shews that during that time the fall of rain was about the 10th of an inch.

88. The fact that neither the dry nor wet bulb thermometer was in the least affected by the storm, although the clouds swept the ground and the rain fell in torrents, seems to shew that the storm could not have been the result of difference of temperature in the atmosphere, and also that the fall of rain does not result from condensation of vapours alone.

89. The storm passed Glastonbury about 2 o'clock p.m. and Oxford at 20 minutes past 4, the distance traversed by the storm in a little more than two hours being about 76 miles. This was the speed of a 'swift wind' only, and not that of a 'hurricane.' Something beyond this, a pressure greater than the force of the air transferred in a forward

current, must have happened, to cause the mechanical effects recorded. The phenomena of the storm shew, that throughout its course it came on in the general direction of the wind; it was accompanied throughout by dark heavy clouds and enormous rains; there was no increase of the wind till the clouds came over; the violence of the wind and excessive fall of rain were in all cases simultaneous; and as soon as *the heavy rain ceased*, the wind again subsided to about the rate it had blown at previous to the storm. It is therefore evident that the storm was connected with and produced by the passing of the heavy clouds and fall of rain.

90. From the sudden fall in the barometer as the storm passed over, it is evident that a rarefaction prevailed within the clouds to an extraordinary degree; and, although perhaps unnecessary, I may refer to a circumstance which occurred as the storm passed over Glastonbury, to shew that there was a like rarefaction in the storm-cloud at that time:—"A person was sitting in a room, which, besides an outward window, had an inner one, looking into another room or passage; when the storm came on, he felt for a moment or two as if he could not breathe, and at the same time a pane of the *inner* window was blown in and across the room. So it would seem that the air in the room had been drawn up through the chimney. The outward window was not injured."

91. I believe I have now stated enough to shew that the storm (or in fact both) was the result of an intense rarefaction within the cloud; and I trust I have shewn that the theory I propose is worthy of consideration as to the cause of its production. It may be objected that all heavy rains should produce violent winds if the theory be true, but, as before stated (30), much in this respect depends on the height from which the rain falls.

92. On the 9th of August, 1843, a violent hailstorm occurred in Oxfordshire, which did a vast amount of mischief in the neighbourhood of Chipping-Norton and Enstone; destroying the crops to a fearful extent. An account of it was published by the Rev. J. Jordan, vicar of Enstone, who witnessed the storm, and is a careful observer of at-

mospheric phenomena. In describing the approach of the storm, he says: "My attention was arrested by an *extraordinary* and *awful* sound in the air, such as I do not remember ever to have heard before. It resembled, in some degree, the roar of the ocean, or the noise of an ascending bore in a river; it came on steadily for between five or ten minutes, increasing, as it approached, in intensity." And he further remarks, that "the most remarkable phenomena connected with this storm were the immense size of the hailstones, and the *extraordinary roar*, quite distinct from the intonation of thunder, or the rustling sound of wind, that heralded the approach of the storm. In this respect the storm resembled the late storm in Wiltshire, as also in the indication of a copious discharge of electricity *by conduction* from the clouds (81), as the reverend author states that 'several of the labouring people in the fields, and others who were overtaken by the storm, would assure him, that they plainly discovered the smell of sulphur in the air.'"

93. Now although on these points this storm resembled the late one, they totally differed in respect to the wind, for as this storm came on it was hardly perceptible, the storm rising in the very teeth of it; the direction changing into that of the storm as it passed over. This absence of wind may, I believe, be fairly attributed to the great height of the clouds, a fact which Mr. Jordan alludes to several times, and particularly states that "the storm rode so *extremly high*, that he felt relieved from all fear of the lightning;" "the clouds were dense heavy masses, such as he had seldom seen," "which seemed to darken the whole atmosphere, as if a pall overhung it, but all the while the horizon, along the tops of the hills, presented a band of light of a sombre hue; relieving the darkness of the clouds, and forming light ground for the exhibition of their changes." I myself, at Oxford, observed the clouds in the direction where the storm was going on, and noticed that the dense cumulus clouds seemed to be higher than any clouds of the kind I had ever before observed; and the rain-drops, which only fell here and there, were the largest; falling heavily on the

pavement, and forming dark patches of four or five inches in diameter.

94. The hailstones which fell in this storm were of enormous size, and totally different in form from those that fell in the Wiltshire storm. The average size of those measured by Mr. Jordan "was a circumference of six inches. Eight weighed together were exactly one pound, averaging two ounces each, and on being melted produced rather more than three quarters of a pint of water." "The general figure of the stone was that of our earth—an oblate spheroid, very much compressed at the poles by its generation round its axis. The compression was very great, the diameter through the minor axis being at least one fourth less than that through the major, and in some instances still less." "The centre of each consisted of a white opaque mass, like compressed snow, yet not sufficiently so as to have become translucent ice;" this was enveloped in various bands of icy structure, the outside being roughened as if it was encased with drops of rain frozen on the surface. This form shews that hailstones had a rotatory motion while falling, and it is to this rapid rotation of the hailstones in the course of their formation and fall, that Mr. Jordan attributed the peculiar roar as the storm came on.

95. I see nothing in the phenomena of this storm that accords with the views advanced by Mr. Espy on the formation of hail: the storm occurred in excessively hot weather, and there is no evidence of violent upward currents, which, according to his theory, are necessary for the production of hail. But I submit, that the theory I propose (26) does afford a probable explanation of the phenomena in question, i. e. "that the escape of electricity from clouds at great elevations, causing the particles of vapour to form drops at a height far above that at which rain is usually produced; these, from the low temperature at such elevations would be instantly frozen and form hailstones, which would increase in size by the accumulation of more particles of vapour during their fall." The centres of the hailstones in this storm were not composed of solid ice, but seemingly of com-

pressed snow; yet the theory holds good, as it is easy to conceive that on the sudden escape of electricity from the frozen particles, they would be driven about in the rarefied space so as to form balls of snow, which, in falling through the "dense heavy masses" of cloud below, would acquire the enormous size and force with which they reached the ground.

96. The rotation of the hail while descending may be readily accounted for; for as the centre was composed of compressed snow, the continual accumulation of more compact ice on the lower surface of the hail while falling would cause a continued change of the centre of gravity in the hailstone, and thus a rotation round its minor axis would be produced, and the compressed spheroidal form would result.

97. In conclusion, I beg to observe that I have controverted the opinion that the storm in Wiltshire was a whirlwind, from a firm conviction that its phenomena must be otherwise accounted for, and with the hope of directing attention to phenomena in storms that are too often overlooked; but I believe that a whirlwind may often result from causes similar to those to which I attribute this storm, as the rarefaction within a cloud, at a moderate elevation, may often produce a whirling of the air rushing onward and upward into the partial vacuum. I have controverted Mr. Espy's opinions on some points, but I believe the phenomena of the storm fully accords with his conclusions, "that there is an inward motion of the air towards the centre of storms from all sides:" I only differ from that gentleman as to how such an effect is produced. The like remark will apply to my observations on Mr. Hopkins' views, as I believe he has, in his various papers on this subject, almost *proved* that the fall of rain is the principal cause of wind, although I have totally different views as to the reason why it is so.

*** The figures of hailstones are given as representing their general form and size, as of course the angles were not preserved so strictly as represented.

By the same Author.

Shortly will be published, a Second Edition of

AN ESSAY ON THE BENEFICENT DISTRIBUTION OF THE SENSE OF PAIN.

"In this relation a paper well deserves to be studied, presented lately to the Ashmolean Society at Oxford, and printed in the last Number of Professor Jameson's *Edinburgh Philosophical Journal* (Oct. 1847.): *On the Beneficent Distribution of the Sense of Pain*, by Mr. G. A. ROWELL."—From an article "On Death as connected with the Fall." By the Rev. John Pye Smith, D.D.—*Journal of Sacred Literature*, vol. i. p. 169.

"Its object is to show that sensibility to pain, instead of strictly following the variations of organisation, is subject to special limitations in different classes of animals, and is, in fact, bestowed only just so far and in such a direction as is necessary for the preservation and well-being of each particular species. This position is illustrated by a variety of curious anecdotes, mostly the result of the author's own observation. The tone of the whole is excellent."—*Guardian, Nov.* 11, 1857.

"It is not an anatomical description of nerves, or a discussion upon their functions; but a series of observations on man and the lower animals, by which the author arrives at the conclusion that the susceptibility to pain is one of the great conservative agents of the animal world. This Essay contains a large amount of curious facts interesting to the naturalist and physiologist."—*Athenæum, Dec.* 19, 1857.

"Similar proofs of benevolent arrangements can be shewn in the very *nature* of its distribution. But the inquiry was too physiological to be introduced into the Sermon. Mr. G. A. Rowell, of Oxford, has treated this particular aspect of the subject in an interesting Essay on *The Beneficent Distribution of the Sense of Pain*."——Foot note to the Rev. A. S. Farrar's *Science in Theology*, Sermon 3. *On Divine Benevolence in the Economy of Pain.* 1859.

This Essay was the subject of an article in the *Quarterly Review* for January 1858.

Published and sold by the Author, No. 3, Alfred Street, St. Giles', Oxford. Price 2*s*. Per post, 2*s*. 1*d*.

By the same Author,

AN ESSAY ON THE CAUSE OF RAIN AND ITS ALLIED PHENOMENA.

"Mr. Rowell devotes the greater part of his work to a close examination of meteorological facts, and shews that his theory is consistent with them all, and affords a more probable explanation of them than any other. We cannot follow him into these details, great as the pleasure has been with which we have perused them, but content ourselves with asserting the justice of his claim that his theory should receive more attention than has hitherto been bestowed on it."—*Spectator, June* 18, 1859.

"It is impossible within the compass of a brief review to give an adequate idea of the ingenuity with which almost all the known phenomena of rain and storms are made to bear tribute to the author's theory. The great variety of facts which the hypothesis succeeds in explaining, renders it almost impossible to doubt that the concurrent testimony gained from the phenomena of evaporation, the suspension of clouds, the formation of rain and hail, the peculiarities of thunderstorms, and other natural phenomena, can only be accounted for by the supposition that the hypothesis involves certain elements of the true theory—or, to speak more precisely, that it stands in some definite and perhaps simple relation to the actual truth."—*Saturday Review, June* 25, 1859.

"Mr. Rowell marshals a large category of phenomena and experiments, selected from a wide survey of scientific records. It is impossible for us to go into an adequate investigation of the facts, or even to construct any kind of index to them. The reader must be referred to the important work before us."—*The Leader, July* 2, 1859.

"Those of my own readers who are interested in meteorological theories will be glad to know that the views of Mr. Rowell, an intelligent and independent self-educated thinker, whose doctrines have been more than once discussed at the British Association, have now been put forth in a more complete form with every desire on the part of the author that they should be fully and fairly canvassed. We do not take upon ourselves to pronounce upon their value, but we cannot refuse our testimony to the modesty with which they are propounded, and to the scientific knowledge which is adduced in their support."—*Westminster Review, July* 1859.

Published and sold by the Author, No. 3, Alfred Street, St. Giles', Oxford. Price 5*s*. Per post, 5*s*. 4*d*.